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Article

Green Infrastructure and Slow Tourism. A Methodological Approach for Mining Heritage Accessibility in the Sulcis-Iglesiente Bioregion (Sardinia, Italy)

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Abstract: In European countries many measures are carried out to improve the disadvantaged conditions and socio-economic marginality of rural areas in comparison with central places. These conditions also affect the quality of travel for visitors and tourists. Therefore, in response to a 'new' tourist demand, motivated also by the restrictions following the spread of the Covid-19 virus in recent years, the institutions and the different local actors are working more incisively to improve rural areas. The rural tourism services offer, combined with the Green Infrastructure (GI) project, at different scales - from local to regional - prove to be interesting territorial development strategies to achieve the Agenda 2030 objectives. This contribution considers the Sulcis Iglesiasiente - Guspinese area, in the Sardinia Region (IT), as a case study. In this area, the landscape context is marked by past mining activity and the project of a path of historical, cultural and religious values has proved to be an activator of regenerative processes, in environmental, social and economic terms. The present study proposes a methodological approach to develop an index (FI - Feasibility Index) to assess the feasibility of the Stop Places (SPs) schemes along a horse trail to integrate the current slow mobility by bicycle and pedestrian in the bioregion.

Keywords: green infrastructures; slow tourism; rural tourism; bioregion

1. Introduction

According to UNWTO, rural tourism is a “type of tourism activity in which the visitor’s experience is related to a wide range of products generally linked to nature-based activities, agriculture, rural lifestyle/culture, angling and sightseeing” [1]. This type of tourism can be combined with the slow philosophy of travel that suggests a non-invasive and sustainable use of space. In the rural context, this approach is a priority for local actors who are planning their landscapes under the banner of economic competitiveness and the protection of natural and cultural resources. Slow movement normally takes place along specially created or 'recovered' paths that represent the essence of the place. The rediscovery of identity traces and the consequent development of projects consider the territory as a common resource/service on which the well-being and quality of life of the resident and host population depends. In this profile the value of common pool resources is combined with that of green infrastructures that assume the role of 'glue' between natural and semi-natural areas, agricultural and built-up areas.

The Green Infrastructures (GIs), at local and scales, prove to be increasingly strategic in achieving the objectives of the 2030 Agenda. According to the European Commission (EC), a GI is “a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services [2]. It incorporates green spaces

- or blue ones if aquatic ecosystems are concerned - and other physical features in terrestrial - including coastal - and marine areas" [3]. Moreover, GIs can provide multiple environmental, social, and economic benefits. These include paths and other infrastructures for slow mobility.

The EU strategy for green infrastructures (2019) [4] confirms that the connection of natural capital in Europe is to be strengthened. In this sense, the quality of the GIs, understood as a provider of ecosystem services (ESs) and as a system well integrated and spatially connected, has a significant effect on the conservation and improvement of the environment [5]. This is why integrating the GI objectives into strategic planning processes and spatial planning tools is an absolute priority [6].

Another aspect to consider is that the projects of paths and cycle paths, which constitute the network to favour slow mobility [7], contribute to the realization of GIs, recognized as drivers of territorial regeneration.

This is what is emerging in the Sulcis-Iglesiente bioregion, located in the South-Western part of the Autonomous Region of Sardinia (Sardinia Region) in Italy, went through a phase of economic conversion based on sustainable slow tourism development [8–10] referred to abandoned mines [11].

Within this framework, the objective of this manuscript is to define a methodological approach to develop a Feasibility Index (FI) to assess the feasibility of the Stop Places (SPs) project scenarios along a horse trail to integrate the current slow mobility (walk and bike), improving the accessibility of a mining heritage. The paper is organized as follows.

1. First section—Introduction and Literature review—focuses on the overview of the recent literature of GI and of its integration with slow tourism and bioregion concepts;
2. Second section—Materials and Data—discusses the topic of green infrastructures and slow mobility in the Sulcis-Iglesiente region and presents principles and approaches for horse trails planning;
3. Third section—Methodology—proposes a methodological approach to assess the feasibility of the Stop Places (SPs) scheme along a horse trail;
4. Fourth section - Case Study - is dedicated to the methodology application in the Stop Places (SPs) along a horse trail in the Sulcis-Iglesiente bioregion;
5. Fifth section—Results—reports and discusses the main research results carried out.
6. Sixth section—Discussion- discusses the major findings within the framework derived from the literature review;
7. Seventh section—Conclusion and Future Development - is dedicated to the conclusions together with the future developments of the research.

1.1. Rural and Slow Tourism, Green Infrastructure

With 83% of the total land area of the European Union (EU), the rural world is home to some 137 million inhabitants (30% of the total population) and is characterized by its landscape diversity. These diversities are also expressed through multiple weaknesses linked to depopulation and a weak socio-economic network. In the last twenty years, in order to counteract the elements that increase the peripherality of these areas in relation to urbanized areas, Europe has outlined an agenda of action plans and programmes focused on growth, employment and the sustainable development of spaces. However, the implementation of Agenda 2000 has triggered several reforms of development and cohesion policies also in the agricultural sector, which has seen a new model based on the multifunctionality of the rural territory [12–14]. In particular, the diversification of the rural economy, in addition to placing the agricultural production sector in a new framework, has made it possible to address with greater attention the critical issues related to environmental protection and the quality of life of native communities [15]. In addition, from the restrictions of the Covid-19 pandemic, the EU supports the rural world through the European Agricultural Fund for Rural Development 2021-2027 (EAFRD): funding that can be spent by the different Rural Development Programmes (RDPs) at national and regional level to foster inclusive, cohesive and sustainable development [16].

The opportunities for rural territories to improve local development can be seized in the diversified panorama of sustainable tourism activities. In particular, rural tourism explicated in different forms according to the territory and the communities that are involved in it, is prefigured as a tool for the conservation of the landscape, the growth of socio-economic value of places through

a structured offer of goods and services [17,18]. There is no universal definition of rural tourism and through the years there are many definitions enunciated that differ based on the aspects considered such as socio-cultural, administrative, demographic, and economic [19]. In 1998 the European Commission defined rural tourism as "...the activities of a person travelling and staying in rural areas - without mass tourism - other than those of their usual environment for less than one consecutive year for leisure, business and other purposes (excluding the exercise of an activity remunerated from within the places visited" [20].

The multifunctional organization of the rural space thus acquires a new guise where synergies between local operators (public and private) can be expressed through a cultural, environmental, sporting and educational initiatives planning. The activation of this integrated offer plays a fundamental role in the processes of revitalisation and local development because it makes it possible to preserve the territorial identity of the many rural villages and at the same time helps tourists to enjoy an 'experiential' journey [21–23]. According to Eurostat data, in 2021 in the 27 Member States 36% of tourist nights were spent in rural areas that offer around 12 million beds [24]. The choice of a holiday in contact with nature and the authenticity of places is even more motivated by the changes brought to daily life by the Covid-19 pandemic. Health insecurity and restrictions have prompted tourists to seek 'staycation' and 'slow' travel experiences [25–28]. Thus, in response to the criticality of over tourism, rural tourism experiences are combined with the slow philosophy (slow tourism). This last trend, born with the 'slow food' movement allows us to deepen our knowledge of places by perceiving their most authentic aspects. The enjoyment of landscape assets, the respect for the environment and the propensity to use sustainable means of transport are just some of the fundamental characteristics of 'slow' travel - walking, cycling, horseback riding, etc. [29,30]. Furthermore, the experience of slow travel is completed when visitors and tourists choose to travel through destinations following sustainable infrastructures. In this context, the scientific debate on GIs began to appear in the 1990s and today the term plays a key role in policies and strategies aimed at resolving critical environmental issues [31]. Following the debates, several definitions of GIs have been enunciated [32,33]. The European Commission, since 2013, has launched a special strategy to support the green economy through the development of GIs, and has defined them as: 'Green Infrastructure can be broadly defined as a strategically planned network of high quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of ecosystem services and protect biodiversity in both rural and urban settings. More specifically GI, being a spatial structure providing benefits from nature to people, aims to enhance nature's ability to deliver multiple valuable ecosystem goods and services, such as clean air or water" [34]. The Commission published two further guidance documents in 2019 to encourage a more integrated approach and increase investment and planning in this field. These documents reinforce the idea that the sites included in the Natura 2000 Network represent the core of the GI strategy to which were added "[...] biodiversity-rich green spaces such as parks, private gardens, hedges and vegetated buffer strips along rivers or structure-rich agricultural landscapes with certain features and practices, and artificial features such as green roofs, green walls, or eco-bridges and fish ladders [...]" [35].

GI takes the form of an interconnected network of spaces (urban, peri-urban and rural) of significant environmental, cultural and visual value. Its function is to simultaneously preserve and provide environmental services to affected communities which include for example: biodiversity and wildlife, mitigation of air quality, recreation, environmental beauty and protection of disasters [32,36].

Investing in GIs completes the European programme "Biodiversity strategy for 2030" [37] activated to protect Member States' biodiversity. The roadmap for rural spatial planning therefore requires the creation of an ecosystem network where green goods and grey goods and services are integrated in a sustainable way [38,39]. GIs have an ecological, cultural, social and economic function: the resident community is motivated to follow a healthy lifestyle that includes the adoption of sustainable and slow mobility and the possibility of creating spaces of 'community friendliness' more in contact with the natural element [40].

1.2. Bioregion and Sardinia Mining Landscape

The planning of GIs to provide a network of 'new' ecosystem services is part of the vision of the bioregion [41,42]. This term originated in the 1970s along the American West Coast. The authors Peter Berg and Raymond Dasmann (1977) [43] can be defined as the fathers of the concept and the consequent alternative approach that sees localism as an opportunity to safeguard landscapes. The bioregion is defined as a geographical space and 'place of consciousness' in which environmental sustainability, knowledge and conscious management of resources allows for a 're-inhabitation of place' as introduced by Berg in his studies [44]. An environmentalist vision that has since developed in other countries and in the Italian case [45] thanks to the territorialist studies of Magnaghi [46,47]. The bioregion project idea requires an integrated, multidisciplinary approach at different scales capable of strengthening the cultural identity of the area networks while creating a dynamic balance between the different rural and urban centres [48], material and immaterial dimensions [49]. Thus, bioregionalism, in its capacity as a territorial regeneration project, qualifies as an essential paradigm for addressing the critical issues of rural areas.

The island of Sardinia represents, due to its environmental characteristics, a peculiar condition: the geological, paleontological and mineralogical elements, biological rarities and endemisms, forest stands and wetlands, spectacular natural landscapes in the morphology of the coasts and of the internal reliefs, the underground cavities and the archaeological finds make it a small but whole continent. Sardinia is famous in the international mining world for the richness of its geology, of its ore deposits and of its mines [50]. On the 24,000 square kilometers that make up the area of this island, all the geological eras from the Late Pre-Cambrian onwards are represented through an enormous variety of heterogeneous rocks, minerals and fossils. The mining vocation of Sardinia is manifested in the large number of scattered mines on the entire surface of the island, of different productive, scientific, cultural value, but all indispensable for understanding the extraordinary evolution of events which, in more than 8,000 years of uninterrupted events, have marked the history of the use of the territory by of man [51].

From the lower Paleozoic up to present, mineral genetic processes have developed, producing the concentration of metals and minerals of industrial interest, in deposits of different types, genesis and entity. The orogenic events and the imposing granitic intrusions have activated hydrothermal circuits, with deposition of various types of mineralization, such as talc-chlorite and mineralizations with magnetite and sulphide. The deposition of carbonate sediments starting from the Jurassic, was completed at the end of the Mesozoic, when Sardinia emerged completely and several layers of coal deposited in the south-western area (Sulcis), combined in a calcareous-marly succession. The importance of each area, within the framework of mining sites, is related to the development of a particular mineral deposit: from the metalliferous ore deposits to the presence of the important copper mining (Funtana Raminosa), which played a significant role in the history of metallurgy in the Mediterranean area, starting from the Neolithic age. From the zinc and silver metal deposits, exploited since the Roman colonization, to the metallic antimony deposits, exploited since the Phoenician and Punic invasions, which made the area of Serrabus, Gerrei the second island mining district, between 1800 and 1900. The most important mines are present in the so-called "metal ring of the Iglesiente", where lead, silver and zinc mineralizations are located in the carbonatic geological formations which, with over 500 million years, are the oldest paleontological dated rocks in Italy.

The mining activity of Sardinia has primarily involved the communities that have followed one another in the exploitation of subsoil resources; the traces of this industry, which has been influenced by the same historical events of the island, are clearly visible in the territory it has undergone profound changes that currently characterize it. The features of the natural landscape are visibly marked by the material culture, social organizations and settlements that have arisen around the mining activities, which have generated new and original forms of landscape and social and cultural environment, such as to characterize vast areas with a precise identity of value universal, unique and representative of the entire Mediterranean geo-cultural region. Considering all these values, the Sardinia Region, through the Sardinian Mining Authority, has intended to promote, starting from 1997, with the involvement of all institutional subjects authorities, first of all the Local Authorities

concerned, the establishment of the Historical Environmental Geo-mining Park of Sardinia (Geo-mining Park) [52] which includes the most important mining districts, located in the Sulcis Iglesiente Guspinese, but also the most significant mining structures located in other areas of the island.

As part of this renewed awareness, the Santa Barbara Path (SBP) [53] has been established (Figure 1) in the Sulcis-Iglesiente bioregion (2017), as well as the homonymous Foundation - the Santa Barbara Path Foundation (SBPF) [54], which represent a real challenge taken on by local communities themselves and, subsequently, by the local administrations, to promote a virtuous process of territorial transformation.

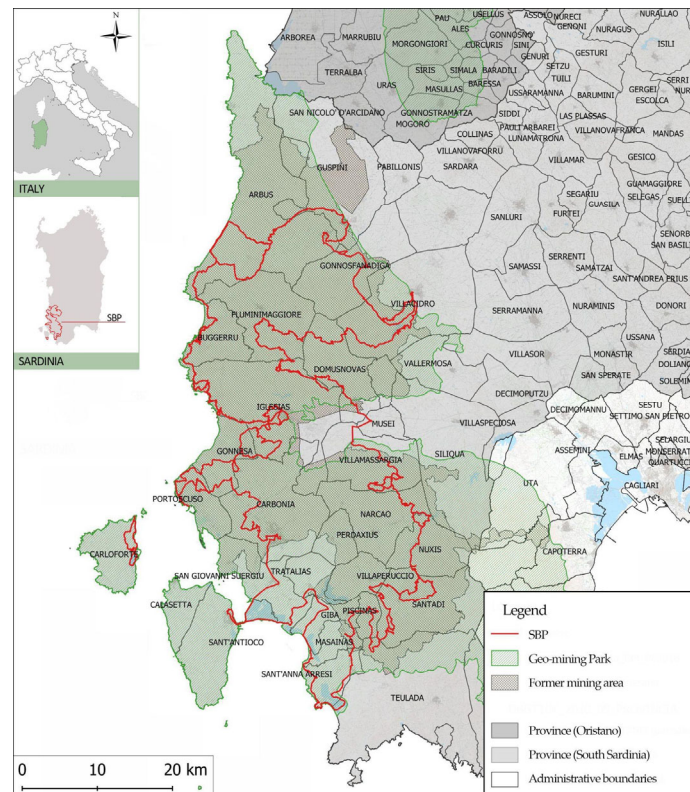


Figure 1. The SBP, in the Sulcis-Iglesiente bioregion (Author: M. Ladu, 2023).

2. Materials and Data

2.1. Study Area - The Santa Barbara Path and horse trail proposal network

The Santa Barbara Path (SBP) is an itinerary drawn in the Sulcis-Iglesiente area, in South-Western Sardinia, an historical region that has been the most important district for national and international mining until the 1990s, when the crisis hit the sector, causing the mines dismantling [55]. As a consequence, the mining landscape is marked by large open-air and underground works, mine adits, tunnels, and numerous mine wastes.

The principal result of this extensive mining activity is the economic depression that required rethinking a new development, also through forms of sustainable tourism [56] capable of enhancing the great heritage of industrial archeology [57] in a particularly beautiful mining and coastal landscape [58].

The SBP, which extends along a 500 km ring, organised in 30 tracks, follows the traces drawn by mining activities in the past decades in a unique landscape in transition —or landscape in progress—, understood as the outcome of different stages of human-nature interaction [59]. In this sense, the SBP represents a response to the demand for a particular type of rural and slow tourism [60] associated with the use of GIs, which in the Sulcis-Iglesiente region (Mining Bioregion) arises as a driving force for economic development.

Over the last few years, the SBP has been included in the regional register of historical-religious walks of Sardinia and in the Atlas walk of Italy of the Ministry of Cultural Heritage and Activities.

In line with the objectives of the Geo-mining Park, the SBPF constantly promotes different types of accessibility as a primary condition for a new development phase based on the concept of rural and slow tourism [61], according to principles that guide the political strategies of the regional level [62]. As a matter of fact, the construction of a horse trail, connected to the SBP and to the cycle path (a thematic route connected to the great cycling network of Sardinia) [63], represents one of the most important projects carried out by the SBPF (Figure 2). The horse trail consists of a ring route of over 500 km, divided into 18 tracks and 19 stop points (SP), which crosses 24 Municipalities.

In this sense, the SBPF intends to enhance the SBP as a GI for rural and slow tourism for several and integrated aspects: recovery of the old mining tracks; provision of different travel way (walk, bike, and by horse); offer of a widespread and low-cost hospitality system, which integrates the existing one. If the project of the tracks is in progress, that of the Stop Places (SP) represents an important challenge.

Following previous research [64,65], the proposal of a methodological approach to develop an index (FI - Feasibility Index) to assess the feasibility of the Stop Places (SPs) scheme along a horse trail to integrate the current slow mobility (walk and bike). referring not so much to the stages, for which the project is already in progress, as to the SPs, understood as the main nodes of a network of routes (walk, bike, horse) to support slow integrated mobility.

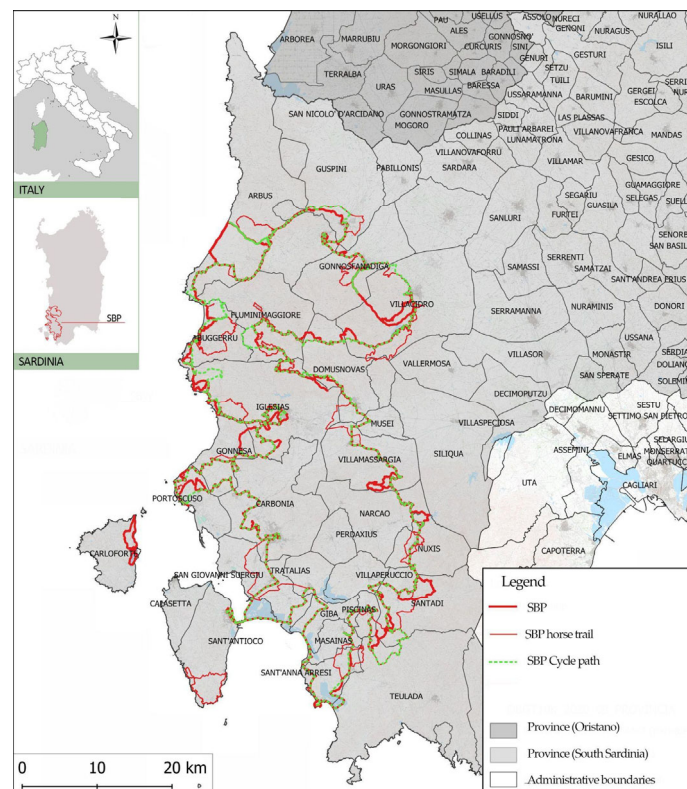


Figure 2. The SBP, in relation with the SBP cycle path and the new SBP horse trail (Author: M. Ladu, 2023).

2.2. Planning horse trails. Principles and approaches

The geographical Italian context hosts several horse trails which differ in various aspects: characteristics of the areas crossed - mountainous, hilly, plain, coastal territory; localization - they may fall within protected natural areas [66,67], along the rivers [68] and, in some cases, follow historic roads and ancient transhumance routes [69] or old railways [70]; length (km); number of tracks; provision of facilities and services along the route to support the riders and the equids themselves;

connection with other existing slow mobility networks [71], as cycle paths and walks [72]. One of the most important is the horse trail in the Gran Sasso and Monti della Laga National Park (Ippovia Gran Sasso - Abruzzo Region) [73], which represents the longest horse trail in Europe (520 km). It crosses 36 Municipalities, following the paths which for centuries have connected villages and towns separated by the Gran Sasso, a massif in the Apennine Mountains of Italy, or which have always been used by farmers. Other notable horse trails in Italy are those that cross regional and national parks such as the Appia Antica Regional Park (Lazio Region), The Maremma Natural Park (Tuscany Region), The Majella National Park (Abruzzo Region); The Alta Langa Park (Piedmont Region). As a matter of fact, recent research confirms the importance of nature in the expectations of horse trail ride tourists [74].

The horse trails planning and management requires the observation of several criteria to ensure the safety and well-being of horseback riders and horses [75,76], according to the environmental context [77]. The main aspects to be considered concern [78]:

- Surface, which should be well-drained, firm, and free of sharp stones or other hazards that could cause injury to a horse's hooves;
- Dimension, which should be wide enough for horses to pass each other safely and free of obstacles that could be dangerous for horses and riders;
- Grade, which should be moderate, with no steep inclines or declines that could be difficult for horses to navigate;
- Signage, which should be clear and include information about trail difficulty, distance, and any potential hazards;
- Maintenance, which should be ensured regularly;
- Equestrian facilities which should include areas for horse camping, loading and unloading horses and parking for horse trailers.

Some important references for the horse trail planning in Italy are (Figure 3):

- The National Board of Environmental Equestrian Guide (ENGEA - Ente Nazionale Guide Equestri Ambientali) guide for obtaining certification. The Certified Horse Trail Classification Index (ICIC – Indice di Classificazione Ippovie Certificate) reflects the degree of difficulty of each horse trail [79];
- The Specification for the design of Italian horse trails drawn up by Italian Equestrian Sports Federation (FISE - Federazione Italiana Sport Equestri) [80];
- The Specification for the design of Italian horse trails certified by the Italiana Equestrian Tourism Federation and Trec-Ante (FITETREC-ANTE - Federazione Italiana Turismo Equestre e Trec – Ante) [81].

This topic is particularly important in Sardinia, where the rural landscape constitutes the connective structure of the wider scenario of the regional landscapes [82], which has long been at the core of territorial development policies.

The Sardinia Region, with Regional Law No. 16/2017 [83] recognises the use of equines (horse and donkeys) for enhancing the tourist and environmental heritage of Sardinia. This is possible through specific interventions aimed at the creation of a network of horse trails and the functional recovery of facilities for logistical, resting and support needs of riders and animals. Specifically, Article 28 of the Law defines technical criteria regarding the Network of Hiking, Bicycle Hiking and Horse Trails. The Sardinian Horse Trails Network (RIS - Rete delle Ippovie della Sardegna) represents a subset of the paths of the Sardinian Hiking Network (RES - Rete Escursionistica della Sardegna) for which the walkability on horseback is validated. The measure also establishes a special regional register of Sardinia's horse trails. The updating of this register is regulated by the Plan for the Establishment and Management of the Sardinian Hiking Network (RES), under the coordination of the Regional Forestry Agency for Land development and environment of Sardinia (FoReSTAS - Agenzia forestale Regionale per lo Sviluppo del Territorio e l'Ambiente della Sardegna).

Indeed, horse trails find wide application in Sardinia because there is a long tradition of horse farming and some races are particularly suitable for trekking [84].

According to FISE and FITETREC-ANTEA, the SPs along the horse trail are defined as the system of facilities that provide hospitality for riders and/or shelter for horses in boxes, stalls, pens, suitably equipped with water and hay, which guarantee their safety and well-being.

In addition, ENGEA identifies the following types of accommodation facilities (Farmhouses, Hostels, Guesthouses, Refuges, Hotels or Clubs), and the minimum characteristics of each one. This leads to the definition of four main types of SPs, which combine different services to support riders and horses.

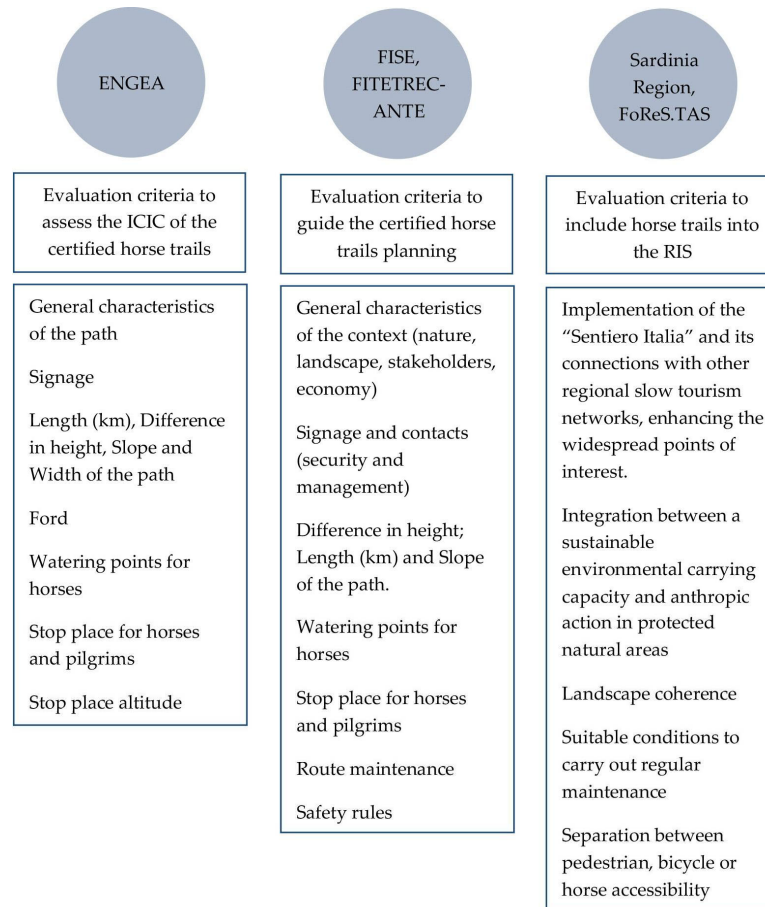


Figure 3. Evaluation criteria for the horse trail planning. Italian references (Author: M. Ladu, 2023).

The first ENGEA certification in Italy was awarded in 1998 to the horse trail "On the Griffon's Route" in Sardinia. The "Magical Cala Luna Beach" horse trail is also included to date [85]. The first one is 130 km long and runs from the city of Alghero to the Sale Porcus Oasi in the Sinis peninsula (Province of Oristano), crossing one of the most internal stretches of the west coast, which is highly interesting for its landscape. The horse trail, which is an average difficulty, thanks also to its modest elevation gain ranging from 0 to 780 m asl, can be covered in 7 days. The second one, with a length of 136 km, crosses a complex territory, from the internal areas of the Barbagia (Supramonte mountains of Orgosolo, Baunei and Urzulei) to the east coast (beach of Cala Luna) recording a difference in altitude ranging from 0 to 1,200 m asl. The horse trail, of medium-high difficulty, can be hiked in 3 or 5 days.

At the Regional level, one of the most ambitious projects concern the "Costa-a-Costa" horse trail [86] which crosses central Sardinia from the east coast to the west coast. This path mostly retraces old mule tracks and itineraries existing between beaches, Mediterranean scrub, wilderness and internal prairie. Each SP ends with the stabling of horses and the welcoming of riders. The horse trail, about 135 km long, is divided into six tracks.

The Regional level horse trail system is also expanding thanks to the interventions financed by the Sardinia Region to increase the RES and RIS [87].

The proposal for a new SBP horse trail in the historic Sulcis Iglesiente region is part of this renewed awareness on the opportunity of horse tourism, in addition to walk and bike.

3. Methodology

Moving in the research field focused on the accessibility of mining heritage and geosites [88,89], this study proposes a methodological approach to develop a Feasibility Index (FI) to assess the feasibility of the Stop Places (SPs) project scenarios of the horse trail, in terms of Internal Coherence (IC) criteria and External Coherence (EC) criteria, to integrate the slow mobility (walk and bike).

In line with the methodological approach adopted in recent studies to define complex index for supporting urban policies and planning [70] and developed by the authors themselves in previous research [61] to define a set of indicators to assess the attractiveness index of the SBP tracks, the methodology consists of three quali-quantitative phases (Figure 4):

1. Phase_01 - which develops a typing matrix according to a set of typing elements selected by the literature review and practices analyzed. The typing matrix allows each SP to be analyzed according to landscape, infrastructure, N. of functions, rank and ownership characteristics, from which specific project scenarios are derived (output);
2. Phase_02 - which defines a coherence matrix according to a set of Internal Coherence (IC) criteria and External Coherence (EC) criteria for each SP's project scenario. The IC criteria, which refer to the intrinsic characteristics specific to each SP project scenario, are: the number and variety of functions, the intervention types planned (maintenance, restoration, new construction), the building time required (short, medium, long), and the circular solutions (water, energy, etc.) adopted. The main EC criteria, which refer to the external factors specific to the SP context, are the environmental and landscape constraints and the local planning regulations in force;
3. Phase_03 - which defines the Feasibility Index (FI) of SP's project scenarios, through a quantitative criteria aggregation.

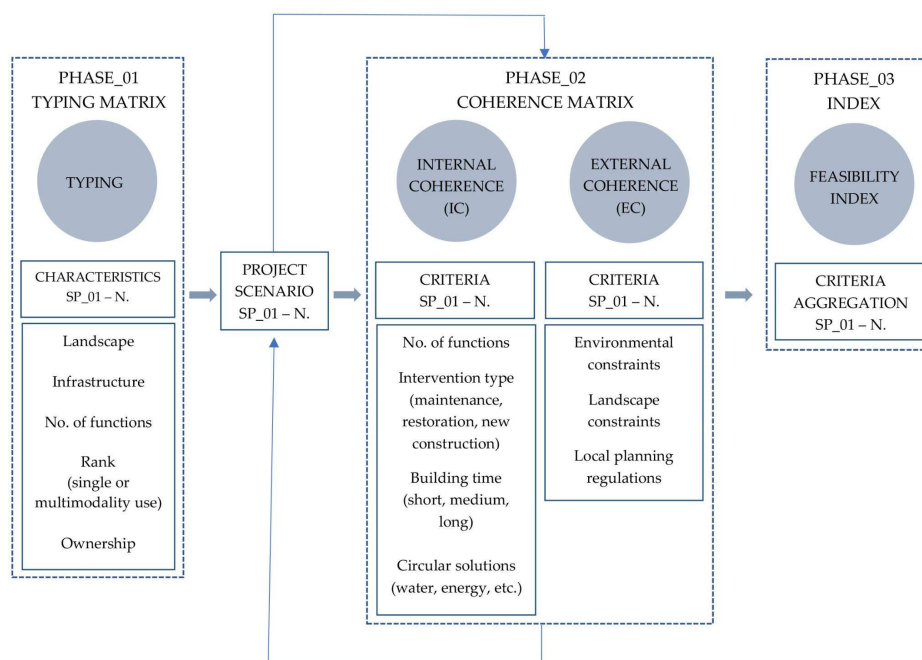


Figure 4. Methodological framework (Author: M. Ladu and Ginevra Balletto, 2023).

The methodology provides feedback between the phase 2 and the project scenarios (output). As a matter of fact, a possible lack of coherence with the IC and EC criteria, such as the incompatibility with the regulatory framework, may require the need to redefine the project scenario.

The IC and EC criteria meet the objectives at the core of various case studies examined (Section 2.2), primarily that of the SBPF, which are in line with the 2030 Agenda Sustainable Development Goals (SDGs). They may be summarized as follows:

- The sustainable planning of horse trails, as well as that of paths (walk and bike) to support the regeneration of former mining landscapes and deprived internal areas, in order to guide a new course of development based on rural and slow tourism (Goal 3; Goal 8; Goal 9; Goal 13; Goal 15; Goal 17);
- The reuse of the existing buildings (mainly heritage of industrial archaeology, properties of abandoned mining villages) to ensure a network of accommodation facilities for the well-being of pilgrims (by walk, bike and horse) and horses (boxes, paddocks and support services), in order to realize the SPs during the short to medium term, thus reducing the time for the commissioning of the horse trail (Goal 11; Goal 12; Goal 13; Goal 15; Goal 17);
- The compliance of the SPs project scenarios with the multifunctionality and circularity criteria, through the redevelopment of existing buildings aimed at achieving water and energy self-sufficiency, and the realization of equipped areas for horses stabling, with primary services (ex: water and energy self-sufficiency, water recovery and waste recycling). Such conditions are key prerequisites for ensuring environmental and economic sustainability even in the subsequent phase of use and management of the horse trail and its SPs (Goal 6; Goal 7; Goal 11; Goal 12; Goal 13; Goal 15).

3.1 Feasibility Index - FI

The Phase_03 is dedicated to the definition of the FI [90] of the SP project scenarios through assigning specific weight to the criteria of IC and EC. In particular, the FI can be defined as a half of the sum of the weighted sum (p_i and p_e) of the IC and EC as below.

The proposal of the quantitative index (FI) relating to a SP scenario project is closely linked to the coherence IC and EC which constitute the main feasibility assumptions.

$$FI = \frac{1}{2} \left[\frac{\sum_{i=1}^n (p_i * IC_i)}{\sum_{i=1}^n IC_i} + \frac{\sum_{e=1}^n (p_e * EC_e)}{\sum_{e=1}^n EC_e} \right] \quad (1)$$

where $I = 1, 2, 3, \dots, n$; $k = 1, 2, 3, \dots, n$

where $0 \leq p_i \leq 1$ e $0 \leq p_e \leq 1$

$0 \leq FI \leq 1$

The weight assignment to each criteria (IC and EC) have the following characteristics: p_i and p_e tend to 1 when the SP project scenario meets full IC and EC.

In particular, if $FI = 0 - 0.25$, it represents a critical scenario (Level 4); if $FI = 0.26 - 0.50$, it represents an average critical scenario (Level 3); if $FI = 0.51 - 0.75$, it represents an average positive scenario (Level 2); if $FI = 0.76 - 1$, it represents a positive scenario (Level 1).

4. Case study

The above methodology was applied to three SPs of the horse trail of SBP. These fall in three different municipalities in the South Sardinia Province, within the perimeter of the Geo-mining Park DM 08/09/2016 (Figure 5):

- SP_04 "Posada Pitzinurri", municipality of Arbus;
- SP_08 "Monti Mannu", municipality of Villacidro;
- SP_14 "Parco is Muras", municipality of Giba.

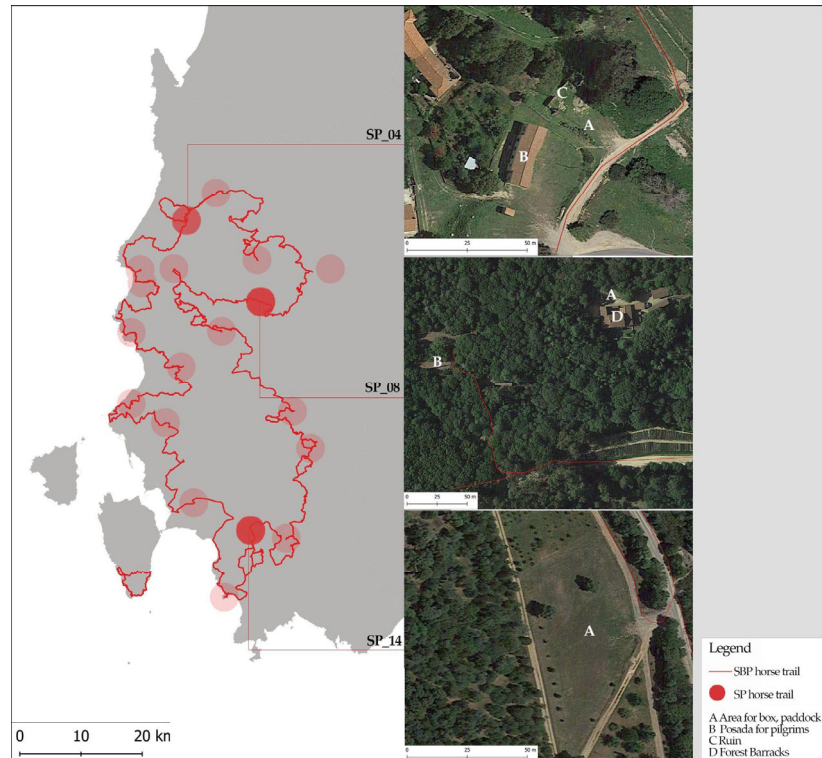


Figure 5. Framing of the SPs along the horse trail, selected as case studies (Author: M. Ladu, 2023).

These three SPs have been selected by virtue of their geographical, landscape, physical and functional characteristics. A more detailed description is presented below.

SP_04 "Posada Pitzinurri" falls in the former mining village of Pitzinurri, in the Incurtosu area, in the Municipality of Arbus. Located in the SP is a building acquired thanks to the agreement signed between the SBPF and the Municipality of Arbus, already used as accommodation for SBP users and, therefore, for the overnight stay of riders of the future horse trail. Along the SBW, accommodation facilities for the well-being of pilgrims (by walk, bike and horse) are called 'Posadas' (small accommodation). Adjacent to this facility, which is named "Posada di Pitzinurri", there is an area containing stone structures, in a ruined state, that is, remains of ancient mining buildings. These structures can be found on the left bank of a small river called "Riu de Naracauli" that flows into the artificial lake of Pitzinurri. Measures to restore the structures, combined with those to excavate and consolidate the bank, would provide space for horse stalls.

However, SP_08 "Monti Mannu" falls within the Monti Mannu forest, which is a naturalistic, environmental and forest complex of Monti Mannu-Oridda-Marganai, in the municipality of Villacidro. In the SP, which is larger than the previous one, there is the old "Locanda del Parco", a building that since 2018 acquired by the SBPF. The locanda has been designated as accommodation (Posada) for SBP users and overnight stays for riders of the future horse trail after the restructuring works. Approximately 120 meters away from this structure, which is named "Posada di Monti Mannu", is the forest compendium consisting of a main building (Forest Barracks) and its outbuildings. In addition, there is a partially equipped area for equids to rest.

The SP_14 "Parco is Muras" lies in an area earmarked for Municipal Park parking lots ("Parco is Muras"), in the municipality of Giba. In a partnership with the Municipal Administration, a portion of the area, where the terrain is likely to be flat, will be used to accommodate equids that will ride the SBW horse trail. Compared to the SPs previously considered, no accommodations for pilgrims insist on SP_14, and also no buildings to be redeveloped or rehabilitated.

The application of the three phases of the methodology described above is shown below. Specifically, Figure 6 and Figure 7 report the typing matrix (Phase_01) and project scenarios, and the

Internal Coherence (IC) and External Coherence (EC) matrix (Phase_02), respectively, related to the following SPs: SP_04, SP_08, SP_14.

For Phase_01, the main data source for typing the three SPs are the Sardinia Region website [91], the SBPF, the cadastre website and the authors themself, who produced data through desk analysis and on-site surveys. The project scenarios (output) proposed are the result of the joint work carried out by the SBPF and the authors themself (Figure 6).

PHASE_01 - TYPING MATRIX						
			SP_04	SP_08	SP_14	DATA SOURCE
TYPING	Landscaping	Environmental	✓	✓	✓	Sardinia Region website
		Anthropic	✓	✓	-	
	Infrastructural	Ports, airports, railways	-	-	-	
		Road network	✓	✓	✓	
		Water supply network	✓	✓	-	
		Electric distribution grid.	✓	✓	-	
	Functional	Buildings and/or areas for horse well-being (horse-box, paddocks and other services)	✓	✓	✓	Authors SBPF
		Buildings for pilgrim well-being (accommodation and other services)	✓	✓	-	
		Buildings for other services	-	Forestry barracks and other buildings	-	
	Of rank	Single mode (only for pilgrim by horse)	-	-	✓	Cadastre website
		Multimodal (for pilgrim by walk, bike, horse)	✓	✓	-	
	Ownership	Public property	✓	✓	✓	
		Private property	-	-	-	

↓

OUTPUT					
		SP_04	SP_08	SP_14	DATA SOURCE
Project Scenario	Buildings and/or areas for horse well-being (horse-box, paddocks and other services)	✓	✓	-	Authors
	Buildings for pilgrim well-being (accommodation and other services)	✓	✓	-	
	Equipped areas for horse well-being (horse-box, paddocks and other services)	✓	-	✓	SBPF
	Buildings for other services		✓	-	

Figure 6. Typing matrix and project scenarios related to the case studies (Author: M. Ladu, 2023).

For Phase_01 (Figure 6), it can be seen that the typification of the three SPs allows for the development of specific project scenarios (output). In the SPs in which no buildings to be redeveloped or rehabilitated insist, the project scenario coincides with the construction of equipped areas for boxes and paddocks; in the SPs where there is a building stock already used for housing or to be redeveloped or recovered for accommodation or other services, the project scenario contemplates the construction of facilities for animal welfare (boxes, paddocks and support services), facilities for the well-being of pilgrims (by walk, bike and horse) and other services to support the users of the horse trail in addition to the ones mentioned above.

For Phase_02 (Figure 7), the data source corresponds to the SBPF and the authors themself, who implemented a set of criteria for the IC and EC matrix.

PHASE_02 - COHERENCE MATRIX						
			SP_04	SP_08	SP_14	DATA SOURCE
IC Criteria	No. functions	Buildings and/or areas for horse well-being (horse-box, paddocks and other services)	✓	✓	-	Authors SBPF
		Buildings for pilgrim well-being (accommodation and other services)	✓	✓	-	
		Equipped areas for horse well-being (horse-box, paddocks and other services)	✓	-	✓	
		Buildings for other services	-	✓	-	
	Intervention types (Presidential Decree 380/2001, Art.3; Art. 6)	Free building activities for the construction of horse-box, paddocks and other services	-	-	✓	
		Ordinary maintenance, extraordinary maintenance or building renovation of existing buildings	✓	✓	-	
		Restoration and conservative rehabilitation for the recovery of the ruins	✓	-	-	
		New Construction (NC)	-	-	-	
	Building time	Short term	-	-	✓	
		Medium term	✓	✓	-	
		Long term	✓	-	-	
	Circular solutions (technological performance of buildings)	Water and energy self-sufficiency	✓	✓	✓	
		Water recovery	✓	✓	✓	
		Waste recycling (organic material from horses)	✓	✓	✓	
Soil permeability		✓	✓	-		
EC Criteria	Regulatory Framework	Environmental constraints	✓	✓	✓	Sardinia Region website Local authorities
		Landscape constraints	✓	✓	✓	
		Local plan in force	-	✓	✓	

Figure 7. Coherence matrix: IC and EC criteria related to the project scenarios developed for each case study (Author: M. Ladu, 2023).

It is important to underline that the intervention types (IC criteria) are those defined in Italy by the Presidential Decree 380/2001 (Art.3; Art. 6) and subsequent additions:

- Ordinary maintenance (MO - Manutenzione Ordinaria), extraordinary maintenance (MS - Manutenzione Straordinaria), building renovation (RE - Ristrutturazione Edilizia) of existing buildings;
- Restoration (R - Restauro) and conservative rehabilitation (RC - Risanamento conservativo) for the recovery of the ruins;
- New Construction (NC);
- Free building activities for the construction of horse-box, paddocks and other services (EL-Edilizia Libera).

The regulatory framework indicated to assess the EC of each SP consists of:

- Environmental constraints, relating to the presence of protected natural areas (oases, regional or national natural parks, Natura 2000 Network sites) and areas managed by the FoReSTAS agency; hydrogeological constraints;
- Landscape constraints, which refer to a comprehensive regulatory framework, at regional and national level, as the Italian Code on cultural heritage and landscape (Law enacted by decree no. 2004/42) and the Regional Landscape Plan (PPR - Piano Paesaggistico Regionale);
- Local plan in force (land use regulation referred to areas interested by the SP).

The assessment of the Feasibility Index (FI) (Phase_03) requires the determination of specific weights for each Internal Coherence (IC) and External Coherence (EC) criteria, consistent with the SBPF goals (Figure 8).

	Range		Weight	
IC Criteria	N _f	1	P _{i(N_f)}	0.5
		2 - 3		0.8
		4 - n		1
	N _m	1 - 2	P _{i(N_m)}	1
		3 - 4		0.8
		5 - n		0.5
	N _c	1	P _{i(N_c)}	0.5
		2 - 3		0.8
		4 - n		1
EC Criteria	N _{ce}	0	P _e	0
		1 - 2		0.5
		3 - n		1

Figure 8. Attribution of ranges and specific weights to the IC and EC criteria to the SPs project scenarios developed for each case study (Author: M. Ladu, 2023).

The Internal Coherence (IC) criteria and their weights (p_i) can be summarized as follows:

N_f = number of expected functions in each SP (animal welfare facilities, pilgrim accommodation facilities, equipped areas, other services);

if $N_f \Rightarrow n$ the weight $p_{i(N_f)} \Rightarrow 1$, consistent with the goal of providing the greatest number and variety of services and functions at the horse trail SPs: pilgrim well-being facilities (by walk, bike, horse), animal welfare facilities (box, paddock) and other services.

N_m = number of months required for the planned intervention in each SP, to be carried out in the short, medium or long term, through the following typologies: ordinary and extraordinary maintenance (MO, MS, RE, R, RC) of public housing heritage to ensure accommodations and services for pilgrims and places for horses; free building activities for the construction of facilities for animals (EL);

if $N_m \Rightarrow 0$ the weight $p_{i(N_m)} \Rightarrow 1$, consistent with the need to bring the horse trail up to speed as soon as possible.

N_c = the number of circularity requirements of the SP project (water, energy, organic material waste, etc.);

if $N_c \Rightarrow n$ the weight $p_{i(N_c)} \Rightarrow 1$, consistent with the goal of ensuring primary services according to the circular economy principle (water and energy self-sufficiency), water and waste recycling, and soil permeability.

The External Coherence (EC) criteria and their weight (p_e) referring to landscaper constraints, and zoning regulations can be summarized below:

N_{ce} = number of external coherences

if $N_{ce} \Rightarrow 3$ the weight $p_{e(N_{ce})} \Rightarrow 1$, thus the SP project is consistent with landscape constraints and urban planning discipline.

5. Results

The application of the method for assessing the FI to the three selected SPs (SP_04, SP_08, SP_14) gives rise to the following results (Figures 9–11).

SP		Value		Weight		$P_i * CI$	
SP_04	IC Criteria	N_i	3	$P_{i(Np)}$	0.8	2.4	
		N_m	12	$P_{i(Nm)}$	0.5	6	
		N_c	4	$P_{i(Nc)}$	1	4	
	Total		19			12.4	
		Value		Weight		$P_e * CE$	
	EC Criteria	N_{ce}	2	P_e	0,5	1	
	Total		2			1	
		FI (PT_04)					0.57
		Level					2

SP		Value		Weight		$P_i * CI$	
SP_08	IC Criteria	N_i	3	$P_{i(Np)}$	0.8	2.4	
		N_m	4	$P_{i(Nm)}$	0.8	3.2	
		N_c	4	$P_{i(Nc)}$	1	4	
	Total		11			9.6	
		Value		Weight		$P_e * CE$	
	EC Criteria	N_{ce}	3	P_e	1	3	
	Total		3			3	
		FI (PT_08)					0.93
		Level					1

SP		Value		Weight		$P_i * CI$	
SP_14	IC Criteria	N_i	1	$P_{i(Np)}$	0.5	0.5	
		N_m	2	$P_{i(Nm)}$	1	2	
		N_c	3	$P_{i(Nc)}$	0.8	2.4	
	Total		6			4.9	
		Value		Weight		$P_e * CE$	
	EC Criteria	N_{ce}	3	P_e	1	3	
	Total		3			3	
		FI (PT_14)					0.91
		Level					1

Figure 9–11. Computation of the FI value for the SPs: SP_04, SP_08, SP_14. (Author: M. Ladu and G. Balletto, 2023).

The SP_08 achieves the highest FI value of 0.93, followed by the SP_14, with an FI of 0.91. Only SP_04 records the lowest value, with an FI of 0.57. More precisely, FI = 0.93 and FI = 0.91 correspond to a positive scenario (Level 1). At the same time, FI = 0.57 corresponds to an average positive scenario (Level 2).

Contributing to the highest value of FI for SP_08 were: the high number and variety of functions (3); the short time required for the redevelopment and change facilities use, estimated at 4 months; the high number of circularity feature criteria met by the project (4); and the level of EC, highest (3). The SP_14 project scenario, while also having the highest degree of EC (3), as it is consistent with landscape constraints and urban planning discipline, has a slightly lower FI value than SP_08 because it suffers from the absence of an existing building stock capable of accommodating pilgrim well-being services and other functions to support the horse trail. In fact, the only function contemplated by the SP_14 project scenario is the equipped area for the establishment of boxes and paddocks.

Finally, the lower value of FI of SP_04 is mainly determined by two factors: as far as IC is concerned, the number of months required to carry out the restoration work on the structure in the state of ruins, near the Posada, and which could house horse boxes; as far as EC is concerned, the lack of coherence with urban planning regulations.

The scenario presented, which emerged from the proposed method to assess the FI of the SPs along the SBP, highlighted the opportunities that can be generated by the functional reuse of existing

buildings, mainly in terms of the number and variety of services offered for the well-being of pilgrims and horses. The redevelopment of the existing buildings according to circularity criteria also has a strong influence in determining the IC of the scenarios, as well as the timing for the realisation of the interventions. On the other hand, the lowest FI derived by a limited EC, highlights how much coherence with the superordinate constraints and with the urban planning discipline affects in determining the feasibility of the projects.

In light of these results, specific strategies are required to overcome the average positive scenario and, as a consequence, to increase the level of feasibility of the SBW horse trail project. First of all, the SBPF may prioritise the implementation of the SPs project scenarios that record the highest FI, thus reducing the time for the commissioning of the horse trail. Moreover, with reference to SPs project scenarios that record a low FI, if the determining factor is the low number and variety of functions, the SBPF could implement the horse trail planning strategies involving nearby nodes and centralities along the path. At the same time, if the determining factor is the low degree of coherence with existing urban planning regulations, the SBPF may promote concertation processes with the local authorities directly involved.

6. Discussion

Beginning with the analysis of the literature on safety and well-being criteria for riders and horses in the planning and management of horse trails [75,76], and with due respect for the environmental values that characterize the different territorial context [77], this study aimed to define typing and Internal and External Coherence matrices to assess the feasibility of SP project scenarios to be implemented, taking into consideration multiple aspects.

As compared to the literature reviewed in Section 2.2, concerning horse trails planning [79–81,83] and the horse and rider rest well-being facilities design [75,76], this study introduces a set of Internal and External Coherence criteria to evaluate the Sps project scenario. Guided by the approaches of Bambi et al. [75], who have planned two different solutions of structures for the horses observing the principles of low impact, low cost, easy installation and complete reuse, additional Internal Coherence criteria were identified: number and variety of functions, possible interventions, construction time, and circular solutions in both buildings and stalls, including stormwater recovery and self-production of energy.

The criteria were combined through an analytical approach, where specific weights were assigned to each IC and EC consistent with the goals of the promoting organization (in this case, the SBPF), inspired by those of the 2030 Agenda, and the challenges imposed by the ecological transition.

However, this was possible mainly because, as described in Section 2.1, the SBP horse trail project is a work in progress, particularly with regard to SPs. This condition is a prerequisite for the development of methodology. The promoting organization's (SBPF) principles, goals, and priorities are the one that guide the assignment of a specific weight to each identified criterion. Thus, the importance given to multifunctionality, to the reuse of existing building stock, to the short-to-medium time of implementations of interventions, and to circular solutions in defining the SP scenario have had a decisive impact on the calculation of the IF. This takes a sort of priority score considering the objectives of the main stakeholders [70]. The assigning to EC criteria weights, that is, to the constraining framework and urban planning regulations insisting on the SP areas, seems to appear less impactful in directing policies, precisely because these are established and difficult to change.

The decision to propose an FI to assess the feasibility of SPs, intended as the main integrated nodes of a path network (walk, bike, horse) to support horse mobility, highlights how the study makes a scientific contribution with reference to a more circumscribed, but still complementary, dimension of the research field investigating the accessibility of mining heritage and geosites [88,89].

The importance attached to the reuse of existing physical structures [70], including the ancient tracks related to the miners' landscape, are common elements of the main approaches analyzed. These elements add to the necessary and prioritised action of systemic ecological restoration, but also to the recognition of nodes in the complex spatial matrix design of accessible places [88].

Hence, the Sps along the horse trail can also be considered nodes integrating with the other core sites of different value, function and rank. In this context, the Sulcis-Iglesiente's complex and wide bioregion, which is characterised by a significant tie between GIs and mining heritage, is suitable to host the most recent trends of rural and slow tourism, combining the fruition of resources also toward sports activities [92]. The SBW horse trail as a whole (tracks and SPs), like other slow mobility planning perspectives in Italy and beyond [68], may strengthen the spine of a network of ecological services and existing public facilities, enhancing the relations with the small/medium urban centers it goes through according to the specific characters and lifestyles of these contexts..

7. Conclusions and Future Developments

The cohesive goal included in the territorial planning of Countries at an international level has stimulated the creation of different methodologies for 'structuring areas' that should be safeguarded and managed in a sustainable and multifunctional perspective. This study examined the issue related to the slow use of the mining landscape (also in terms of tourism), identifying the creation of a bioregion and the adoption of green infrastructures as useful strategies for re-territorialising rural areas in a particularly sensitive area characterised by a landscape in transition that is a result of ceased mining activity. Furthermore, these initiatives at various levels have contributed to strengthening the current network of protected areas and other effective conservation measures.

In particular, the first section was dedicated to the literature review concerning three main topics which, although represent well-defined research fields, have been investigated according to an integrated approach. We considered the integration of the concept of Rural and Slow Tourism, Green Infrastructure (GI), and Bioregion fundamental to achieve the main purpose of the paper. Such a preliminary phase represented a starting point for developing the following sections.

The second section was dedicated to the analysis of the study area, the Sulcis Iglesias Guspinese bioregion, in the south-western part of the Region of Sardinia, which has already been the subject of previous analyses and field research carried out by the working group. Moreover, the area studied has long been the subject of strategies and policies for territorial valorization at different scales. In addition to the institution of the Geo-mining Park, other examples are the creation of the Santa Barbara Path Foundation (SBPF), the establishment of the Santa Barbara Path (SBP) and the local network. These initiatives enabled a regenerative process of the places in environmental, social and economic terms. Subsequently, the SBPF launched a project aimed at enhancing the existing path (walk and bike) and, more recently, by horse. The horse trail is an itinerary that only partially coincides with the SBP, which is alternated by SPs that serve as equipped stopping nodes.

The third section proposed a methodological approach to develop a Feasibility Index (FI) to assess the feasibility of the Stop Places (SPs) project scenarios along a horse trail. The FI derives from the result of typing matrices and coherence matrices for each SP project scenario, implemented in the fourth section of the paper, where three SPs were selected as the case study to assess the methodology

From the policy maker's point of view, the FI is useful in providing support for planning future actions in a hierarchical way, considering the stakeholder's objectives and the first ambition to carry on the horse trail project as part of a more general perspective aimed at integrating the SBP (walk, bike, horse) with the green infrastructure network, to reap the benefits of adopting multifunctional strategies based on ecosystem services, within the related bioregion. In this sense, the future line of research should take into account the effects of re-territorialisation related to dilute rural identity, diminish place distinctiveness and deplete the cultural and economic sustainability.

Such initial setup of the FI put the basis for the future research and applications.

The future developments of this study will cover the assessment of the FI for all the SPs along the SBP horse trail, in order to guide the whole planning process in an integrated way. The application of the methodology may require the need to modify the set of indicators underlying the definition of the FI. As a matter of fact, the FI assessment here suggested should be implemented in line with the goals, priorities and criteria to be pursued and observed in a particular context, such as that of the Sulcis Iglesias bioregion, characterised by a significant mining heritage.

As a matter of fact The main challenge of this research work lies in the effective collaboration between public bodies involved in the SBP horse trail planning, as well as other local operators interested in investing not only in the tourism sector, taking advantage of the multifunctionality of the context. Furthermore, it is important to underline that the success of the SBP horse trail will also depend on the smart community activities, which, by disseminating and sharing information, promote the SBP and its multi-accessibility (walk, bike, horse).

In conclusion, it is believed that the methodology proposed can represent a reference framework applicable to other territorial contexts to achieve European policy's goals for the medium and long-term landscape conservation and valorization.

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Glossary

EC	External Coherence
ENGEA	Ente Nazionale Guide Equestri Ambientali (Board of Environmental Equestrian Guide)
FI	Feasibility Index
FISE	Federazione Italiana Sport Equestri (Italian Equestrian Sports Federa-tion)
FITETREC-ANTE	Federazione Italiana Turismo Equestre e Trec – Ante (Italian Eques-trian Tourism Federa-tion and Trec-Ante)
FoReSTAS	Agenzia forestale Regionale per lo Sviluppo del Territorio e l'Ambiente della Sardegna (Regional Forestry Agency for Land development and environment of Sardinia).
GI	Green Infrastructure
IC	External Coherence
ICIC	Indice di Classificazione Ippovie Certificate (Certified Horse Trail Classification Index)
RES	Rete Escursionistica della Sardegna (Sardinian Hiking Network)
RIS	Rete delle Ippovie della Sardegna (Sardinian Horse Trails Network)
SBP	Santa Barbara Path
SBPF	Santa Barbara Path Foundation
SP	Stop Place

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